Determining the Optimal C-130 Deployed Crew Ratio

Graduate Research Project

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Abstract

As the Air Force begins to face further budget limitations, every program across the enterprise must be analyzed for efficiencies. Air Mobility Command (AMC) is in the process of trying to find such efficiencies to help mitigate cuts due to shrinking budgets and sequestration. By taking a fresh look at intratheater airlift requirements and historical data, AMC can justify its current C-130 manning and crew shape or find that a new mix can both meet COCOM requirements (retain the needed capability) and become more efficient. The goal of the research is to help guide a discussion within AMC that will determine the optimal deployed crew ratio for a range of possibilities. This will lead to further discussions on proper C-130 squadron manning and appropriate C-130 component makeup (Active, Reserve, and Air National Guard).

The focus of this research is to find the optimal crew ratio for deployed C-130s from both a historic and forward looking perspective. The findings may have a dramatic influence on the shape of the C-130 fleet as AMC seeks efficiencies in force size, manning and the right total force mix between the air reserve component (Air Force Reserve and Air National Guard) and the active duty component. The research contains quantitative analysis in the form of analyzing historical data, and has a qualitative component in the form of questionnaires of past deployed C-130 commanders and directors of operation. Additionally, a high UTE rate scenario is analyzed to aid in warding off a myopic decision based on the experience of OEF, OIF and OND. All of this taken together yields a quant[71]itative decision tempered by less measurable factors to give a holistic view of crew ratio planning.

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DETERMINING THE OPTIMAL C-130 DEPLOYED CREW RATIO

I. Introduction

Background, Motivation, & Problem Statement

As the Air Force begins to face further budget limitations, every program across the enterprise must be analyzed for efficiencies. Air Mobility Command (AMC) is in the process of trying to find such efficiencies to help mitigate cuts due to shrinking budgets and sequestration. When seeking the reasons behind current C-130 unit manning -- and specifically deployed crew ratios -- much of the justification has been lost to time. By taking a fresh look at historic data, expertise in the field and analyzing potential usage scenarios, AMC can justify its current C-130 manning and crew force shape or find that a new mix can both meet Combatant Commander (COCOM) requirements (retain the needed capability) and become more efficient. The goal of the research is to provide an analysis of deployed C-130 crew ratios in order to help guide a discussion among AMC, Air Force Reserve Command (AFRC) and the National Guard Bureau (NGB) that will determine the optimal deployed crew ratio, the optimal manning at C-130 squadrons, and the appropriate C-130 component makeup (Active, Reserve, and Air National Guard). This is a topic that is being discussed at Air Mobility Command as a possible avenue to save substantial amounts of resources. The analysis on this topic arms AMC with a thoughtful starting point that helps ensure that the required capability is maintained to meet war fighting needs. If a cut is required despite the findings contained in this research, the findings provide context for exploring possible mitigation strategies to maintain the required intra-theater airlift level of service to the COCOMs.

Research Focus

The focus of this research is to find the optimal crew ratio for deployed C-130s given a range of operations. The findings may have a dramatic influence on the shape of the C-130 fleet as AMC seeks efficiencies in force size, manning and the right total force mix between the air reserve component (Air Force Reserve and Air National Guard) and the active duty component. Consideration is given to ensuring that active duty and reserve component perspectives are analyzed and included in the research.

The literature review focuses on a few areas to include studies on determining crew ratios for other major weapon systems (focusing on Air Force air assets), currently used planning factors, intratheater airlift demand and less quantifiable aspects of crew ratio planning such as circadian rhythm disruption. The initial review is on subjects that directly relate to the desired research and then broadens to include topics that may have peripheral appeal.

Research Objectives/Research Questions & Hypotheses

While the implications of this research may have a large scope, the specific objective of this research is to find the optimal deployed C-130 crew ratio. The basic theory governing the desired findings is simply a supply and demand issue. The demand side of the equation is driven by COCOM requirements and usage while the supply side is driven by intratheater airlift capability. The supply side has multiple parameters; the basic variables include multiple major weapon systems and the aircrew available to fly the number of airframes made available. This research will only focus on the manning variable for deployed C-130s.

A more specific objective of this research is to develop, or validate an existing, quantitative planning tool for determining the optimal C-130 deployed crew ratio. This will be the means for testing the research hypothesis:

-*The current commonly used 2:1 deployed C-130 crew ratio results in excess flight crews beyond that needed to meet current COCOM requirements.*

-The null hypothesis can also be used: *The currently used 2:1 deployed C-130 crew ratio is the optimal ratio that is needed to meet current COCOM requirements.*

Several questions must be posed to focus the research:

1. What are the historic usage rates for deployed C-130s in the CENTCOM AOR?
2. Has the current crew ratio been able to meet COCOM demand?
3. What factors should be considered when determining optimal crew ratios?
4. How much excess capability exists in theater, if any?
5. If there is excess capability, does it vary by deployed location?
6. If there is excess capability, what is the minimum and/or optimal crew ratio to meet COCOM requirements?
7. Given a high demand usage scenario, what is an appropriate ratio to meet possible future demand?

Theoretical Lens/Methodology

This research has quantitative analysis in the form of analyzing historic flight data, and it has a qualitative component in the form of surveys or interviews of previously deployed C-130 commanders and directors of operations. Further, a scenario analysis is

done using various utilization rates and planning factors. The quantitative data was provided by Mr. Don Anderson, AMC/A9. Mr. Anderson provided flight data via unclassified sources for sorting and analysis. This is an important aspect of the research, but historic records may not reflect the range of possible operations. As such, the analysis of these records is to be tempered by *possible* usage rates based on a range of possible utilization (UTE) rates. In other words, just because the historic UTE rates support a reduction in crew ratios, the possibility may exist for higher UTE rates based on planning factors for future needs. This is an important distinction to draw because commanders must be given the tools to accomplish current mission tempo while retaining the flexibility to meet other possible taskings.

A qualitative element complements the quantitative analysis. This element is accomplished by a questionnaire sent out to current and past deployed C-130 squadron commanders and directors of operation at various CENTCOM locations. The goal of the survey is to gain insight from a key stakeholder group to give context to the quantitative data. This context should have a similar tempering effect to the quantitative data as the analysis of possible future utilization rates. The questions focus on determining possible secondary effects of reducing deployed crew ratios and helping to identify some planning factors that are not resident in the data. Some of these factors include rates of sickness and other shortfalls due to emergencies, disciplinary actions and performance issues. Additionally, opinion questions were included to gauge the interviewees' general thoughts on the subject.

Assumptions/Limitations

An important limitation to recognize is that the research looks at a mix of historic data, reasonable and possible utilization rates and major stakeholders' opinions. Given this focus, the outcomes cannot, by their very nature, predict future needs. Several assumptions must be made to focus the research. First, the assumption that the data received and analyzed is accurate is important. While minor errors are expected due to miscellaneous reasons, these errors will be difficult to locate but will be marginally impactful. Obvious errors and omissions are discarded through data sorting. A second assumption is that the current deployed crew ratio is either the right size or larger than needed. Since C-130s have been operating at the current ratios without controversy or mission failure, the findings should not indicate that a higher crew ratio is necessary to meet current requirements. Third, it should be assumed that the resultant crew ratio calculations will be agnostic of who the force provider is (active duty Air Force, Air Force Reserve or Air National Guard). Fourth, even though there are different crew compliments for C-130Hs and C-130Js, the optimal crew *ratio* will be the same for both variants. Fifth, special missions (Aerial Spray, Firefighting and Weather Reconnaissance), special operations and combat search and rescue C-130s are excluded from the research and findings given their unique mission sets. Sixth, the data analysis is not treated as predictive in nature; it can only be treated as the latest set of data points to be used as a starting point in the analysis. Lastly, the research will consider the currently planned C-130 usage for intratheater airlift as static. In other words, the assumption is that other airframes used for intratheater airlift will not increase their usage rates to make up any shortfall that may exist from a reduction in C-130 availability.

Implications

The potential impact of this research spans a wide range of possibilities. If the current C-130 deployed crew ratio is shown to be the proper size, the findings will support the status quo. This will give AMC leadership peace of mind that the currently fielded C-130 manning is indeed the most efficient. In this case, AMC will have the ability to focus research and resources elsewhere while they seek further efficiencies. However, if it is found that the proper deployed crew ratio is smaller than currently fielded, the implications can be quite dramatic. In this case, AMC leadership should naturally segue into a conversation about the level of in-garrison squadron manning necessary to meet the proposed deployed crew ratio. Further, if a 2:1 crew ratio is supported by the analysis, but reductions are deemed necessary, AMC leadership may use the analysis to help mitigate any issues presented from a reduction and aid in understanding any risk associated with such a decision.

Another major implication is the possibility to move more C-130 capability from the Active Duty component into the Air Reserve Component (Air Force Reserve and Air National Guard) as a cost savings measure. A major limitation in doing this now is that it may be difficult to support current deployment schedules with a higher percentage of C-130s being sent to the ARC because of the difference in deploy-to-dwell ratios between the components. The active component operates at a 1:2 (with a goal of 1:3) deploy-to-dwell while the ARC plans a 1:5 (Stenner, 2011, pp. 5, 10). This means that an active duty member is available approximately twice as often as a member serving in the ARC. Another implication is that AMC may be able to make further adjustments in intratheater capability by using the excess C-130 capability (if it exists) to increase C-130 UTE rates

and decrease other intra-theater assets. Of course, the inverse of this is possible by increasing other asset utilization rates and decreasing C-130 manning and usage. It is clear that this research has a wide range of implications, and it may lead to any number of outcomes ranging from status quo to large changes. The findings will simply arm senior leaders with the analysis necessary to make a more fully informed decision.

II. Literature Review

Chapter Overview

Determining the appropriate crew ratio for a deployed C-130 squadron appears to be fairly straight forward at first look. However, little is written on how one would properly make the determination on the appropriate manning levels for a given situation. The literature review focuses on determining the parts and pieces that would affect the demand for aircrew to aircraft ratio for a given scenario.

Planning Basics

Existing Air Force publications give a baseline for some assumptions that set the stage for the research analysis. The Air Force Pamphlet (AFPAM) 10-1403 is the starting point for an airlift planner; although, discussion of aircrew to aircraft ratios is conspicuously absent. One important piece of information that is contained in the AFPAM 10-1403 is Table 6:

Table 1: Aircraft Utilization[72]

Aircraft Type	UTE Rates[1]		Primary Mission Aircraft Inventory (PMAI)[2]				
	Surge	Contingency/ Sustained	2010	2011	2012	2013	2014
C-130[1]	6.0	6.0	272	231	218	201	193
C-130J	6.0	6.0	70	78	90	98	104

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73]

The six hour surge and contingency utilization rates will be considered the baseline for which an evaluation of proper crew ratio calculations will begin. Additionally, Air Force Instruction (AFI) 11-202 volume 3 sets the limitation on how many hours an aircrew may

fly in a 7, 30 and 90 day time period: 56, 125, 330 hours respectively (Department of the Air Force, General Flight Rules, 2010, p. 63). In addition to the guidance laid out in AFI 11-202 v3, the current US Air Force Central Command (AFCENT) waiver policy is also important to consider since it gives an understanding of how far beyond the AFI 11-202 v3 restrictions mobility leaders are willing to accept in an ongoing contingency operation. While C-130's are not waived under the AFCENT policy like other mobility aircraft, waivers are regularly granted for up to the following 56 hours in 7 days, 150 in 30 and 400 in 90 (Merrill, AMC A9/A9, 2014).

Factors Affecting Crew Ratio

While utilization rate is the main factor that affects crew ratio calculations, other factors such as circadian rhythm and sleep cycle disruption cannot be ignored. The target audience for *Fundamentals of Shiftwork Scheduling* is not necessarily aircrews, but the principles are similar. Topics covered by Dr. Miller include "fatigue, safety, calendar arithmetic, circadian stability…shiftworker satisfaction, the number of workers needed…[and] scheduling methods…" (Miller, 2006, p. vi). All of these topics are crucially germane to the study of crew ratios; some of the quantitative methods used to determine how many aircrews per aircraft are needed do not account for circadian disruption. Disruptions over a long period of time can lead to severe fatigue; this is clearly a concern from an operational risk management perspective.

Next, this research discusses how others -have approached the problem of determining appropriate crew ratios for other major weapon systems. In *Crew Ratio Implications for 24-Hour Warfighting,* Gerald Stiles studies A-10 crew ratios in the wake

of Operation Desert Storm (ODS). St~~G~~iles [74]argues that given the operations tempo for ODS with around the clock operations, aircrew availability became the limiting factor in launching missions as opposed to aircraft availability for the A-10. He created a manpower simulation model to make recommendations on increasing the deployed crew ratio for the A-10 from 1.2:1 to 1.7:1. While St~~G~~iles' [75]quantitative methods differ substantially from the methodology contained herein, his research provides an understanding of possible limitations beyond those readily apparent, such as utilization rates. Additionally, St~~G~~iles [76]argues that his research is "even more critical for other aircraft and vehicle types that have longer sorties or critically timed events" (Stiles, 1993, p. viii).

The *Mobility Capabilities & Requirements Study: 2016 (MCRS-16)* was also reviewed for applicability to the discussion of crew ratios. While there is not direct applicability to a discussion on deployed crew ratios, the MCRS-16 does give some hints about the C-130 crew force as a whole; "[B]ased on current total force planning objectives, the C-130 crew force structure cannot sustain steady state operations in combination with a long duration irregular warfare campaign" (United States Transportation Command, 2010, p. 6). Since one possible implication of reducing deployed crew ratios is the reduction of in-garrison manning or changes in the Air Reserve Component/Active Duty mix, a thorough review of this claim is essential before action is taken.

Scenario Planning

Rand Corporation's *Intratheater Airlift Functional Needs Analysis (FNA)* focuses on determining the appropriate number of intratheater airlift assets to retain in the Air Force inventory in order to meet a variety of needs. While the findings and research do not specifically discuss manning considerations, their analysis is helpful in understanding factors that may drive crew ratio needs. The FNA begins by discussing the current state (as of 2011) of the Air Force's intratheater airlift capabilities. It discusses a possible shortfall of assets given a range of factors. Perhaps the most helpful discussion in the report is a description of factors that could increase intratheater airlift demand in the future. Additionally, there is a discussion of two scenarios, Afghanistan and Indonesia, which paint two very different pictures of how intratheater airlift may need to be utilized in the future.

In the FNA's description of factors that could increase intratheater airlift demand, three main items are discussed: a possible increase in the percentage of resupply via air, an increasingly dispersed nature of operations, and an evolution in future Army CONOPS (Rand Corporation, 2011, p. 15). Firstly, Rand argues the case that operations in Afghanistan and Iraq have "underscored the vulnerability of ground convoys to attack…" (Rand Corporation, 2011, p. 15). While this may be an obvious point to the casual observer, it is still a point worthy of consideration. Further, the point is made that the MCS (Military Capabilities Study) assumes a 5% aerial resupply rate. The point is made that this may need to be amended upward in future operations. The second factor that could increase intratheater airlift needs is the dispersed nature of irregular warfare operations "which translates into multiple, simultaneous, decentralized operations

scattered across huge areas" (p. 16). This is perhaps the most germane point made as it could increase mission length for C-130s performing intratheater lift to support these operations. As will be discussed later, length of sorties is a major driver in crew ratio calculations. The third driver, future Army CONOPS, is discussed by Rand but not included in their analysis because the CONOPS are still under development and being debated.

Rand's FNA is helpful to the study of crew ratio needs by also offering some quantitative analysis of the two aforementioned scenarios. Since a quantitative analysis of Afghanistan operations will be included in the research, the area of most interest in the FNA is how Afghanistan contrasts with a possible operation elsewhere under drastically different conditions. The FNA discusses some unique challenges posed by a possible operation in Indonesia. Specifically, Rand identifies that the "average distance between L3 airfields is about 3.5 times as far [as those in Afghanistan]" (Rand Corporation, 2011, p. 40). L3 airfields are described as forward operating locations (FOLs). Given the direct contrast in operating environment between Afghanistan and an Indonesia type scenario, this analysis aids in estimating utilization rates for what can be considered a worst case scenario.

Rand Corporation also published *Intratheater Airlift Functional Solution Analysis (FSA)* as a follow on to their FNA. Since the subject of the FNA was largely an analysis of hardware needs, the FSA mostly proposes a range of solutions that are hardware based. However, the FSA does include a short section discussing the possibility of increasing C-130 crew ratios as a way to help mitigate the possibility of having too few aircraft. While

this possible solution was abandoned because “reducing the need for C-130s through changes in crew ratio is robust to changes in the scenarios [of different sortie lengths]” (Intratheater Airlift Functional Solution Analysis, 2011, p. 91), their discussion on the subject is helpful to understand some factors that must be included in a crew ratio discussion. Two scenarios are included that show how increasing the crew ratio is helpful for a scenario in which the utilization rate is above the 6 hours offered as a baseline planning factor in AFPAM 10-1403 while it wouldn’t help for a lower utilization rate. The example talks about a hypothetical 12 hour day in which one aircraft flies two 4 hour legs with two 2 hour ground times versus an aircraft that flies three 2 hour legs with three 2 hour ground times. The former would benefit from a higher crew ratio while the latter would not. Reaching back to the discussion on the FNA scenarios (Afghanistan and Indonesia) one can roughly apply the lower utilization rate with Afghanistan while the higher utilization rate would be more applicable to the Indonesia scenario.

III. Methodology

The starting point for determining the methodology to be undertaken is largely historical. An analysis of CENTCOM AOR bases with a continued presence of greater than four C-130s was done to ascertain trends in requirements. The definition for "manpower requirement" was taken from Air Force Instruction 38-201, *Management of Manpower Requirements and Authorizations.*

2.1. Overview. By definition, a manpower requirement is the manpower needed to accomplish a job, mission, or program. A manpower requirement can be documented as a funded manpower authorization or an unfunded requirement. A manpower authorization is a funded manpower position on the Unit Manpower Document (UMD). The Air Force considers manpower a resource to support approved programs. Manpower is not a program by itself which can be manipulated apart from the programs it supports. Manpower is a limited resource which is *sized to reflect the minimum essential level to accomplish the required workload* (emphasis added) (Department of the Air Force, 2013, p. 9).

With the above as the starting definition of a manpower requirement, there are three main ways to give form to the right shape of the C-130 manning at deployed locations. The three methods utilized are a historically based quantitative analysis, a survey of previously deployed C-130 commanders and directors of operations, and a basic scenario analysis.

Historic Quantitative Analysis

A quantitative historic analysis of C-130 intratheater airlift in the CENTCOM AOR is the starting point of the analysis. This analysis looks at determining the length of crew days, the number of flights per day, extrapolating how many missions require augmented crews and an analysis of flight hours per mission. The goal of the quantitative analysis is to understand the nature of missions flown by C-130s in the CENTCOM AOR; the data analyzed is all C-130 missions originating and ending within the AOR under a contingency (versus AMC) label. Four locations, two in Afghanistan (Bagram and Kandahar Air Bases) and two in the Arabian Gulf Region (Al Udeid and Ali Al Salem Air Bases) were chosen for initial review. Given the unique mission factors for the two originating regions (Gulf region and Afghanistan), they were analyzed separately to understand and validate how their utilization rates compare with AFPAM 10-1403 planning factors. Calendar year 2010 was chosen as the sample year because it represented the major crossover point in troop levels between operations in Iraq vs. Afghanistan.

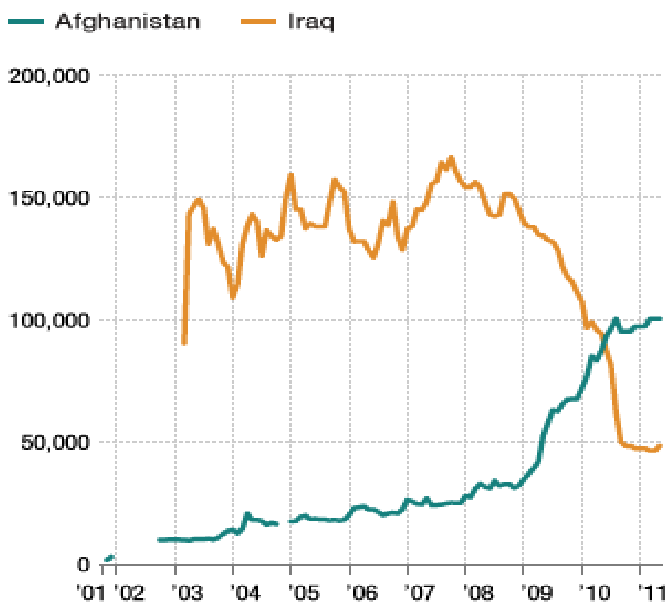

Figure 1: Troop Levels OND vs. OEF

The data was provided by AMC/A9 from the TACC data warehouse (a combination of data from GATES and GDSS) for all of calendar year 2010. The data contained information on all mobility aircraft contingency missions originating from within the CENTCOM AOR and was sourced from only unclassified means. All data was contained within a single excel spreadsheet. The required metrics were extrapolated using the following methods:

1. **Crew Duty Day**: The first takeoff date/time for a single mission number (that may have multiple sorties) was subtracted from the last land time for that mission number. Then, three hours was added to this total for pre-mission duties (mission briefing, life support, armory, customs, transit, pre-flight). For example:

    a. First Takeoff from Al Udeid was 0100 on 1 January

    b. Last Land at was at 1400 on 1 January

    c. Crew day: 1400-0100 (13 hours) + 3 hours = 16 hour crew duty day

2. **Number of ~~Flights~~ Missions per Day**: A count of the total number of missions launched from a location with a discreet mission number. Subsequent legs on the same mission number are considered part of the originating mission and not separate or additional missions. ~~A macro was created to count the first sortie per day per mission number for all of CY 2010. This could be sorted by location by filtering the results by "operating organization."~~[77]

3. **Augmentation Rate**: It was assumed that any mission scheduled with a crew duty day greater than 15.5 hours (determined by the method above) would require augmentation based on restrictions contained in the 11-2C-130 V3 (16 hour maximum flight duty period without augmentation, 18 hours if augmented) (Department of the Air Force, C-130 Operations Procedures, 2012, p. 31).

4. **Flight Hours per Mission**: ~~The macro described above was also designed to sum the flight hours for each mission ID. For example, if a single mission had three legs, the macro summed~~ [78]For multiple leg missions, ~~the three~~ flight times ~~to render the total flight hours per discreet mission ID.~~for all legs are summed.

After an initial review of the data, it was decided to focus analysis on two locations: Al Udeid Air Base and Bagram Air Base. Al Udeid was chosen to represent the Gulf region over Ali Al Salem because it had longer average mission flight hours. Bagram and Kandahar had similar mission profiles, but Bagram's data set had fewer missing data points making it a better choice for more in depth analysis.

Further, Al Udeid was further segmented into two destination bins: flights into and out of Afghanistan and all remaining missions. While the average utilization rates for Al Udeid for all destinations is important in understanding crew ratio needs for those locations in the current conflict, the segmentation allows for an understanding of how the tyranny of distance could affect utilization rates in future conflicts.

Survey of Past Commanders and Directors of Operation

Secondly, to add some qualitative context, a questionnaire was sent to twenty previously deployed C-130 squadron commanders and directors of operations. These leaders were selected from a list of deployments to two CENTCOM AOR locations: Al Udeid and Bagram Air Bases. Questions were focused on how flight crew and overhead manning was utilized and perceptions of the optimal crew ratio. The questionnaire is located in Appendix C: Commander and DO Questionnaire. The purpose of the questionnaire is to ensure that elements of crew ratio analysis that reside outside of the obvious quantitative boundaries are considered. In other words, this is to guard against getting "lost in the numbers" and forgetting about the human element which is a key component of this research.

Scenario Analysis

Lastly, some basic scenario analysis was done to avoid presenting a myopic view of determining the optimal crew ratio that was solely based on an OEF/OIF/OND scenario. While these operations are the most recent example of a high usage of intratheater airlift, they do not necessarily represent future operations. Without this third area of analysis, an improper recommendation could be made that would create future shortfalls. Below is a list of variables used in the analysis in order to determine recommended crew ratios based on variable inputs:

1. Number of aircraft deployed
2. Planned aircrew availability rate
3. Average UTE rate based on planned flight hours
4. Percentage of missions requiring augmented crews

The foundation of the calculations used was based on Mr. David Merrill's (AMC/A9) work on determining crew ratio needs. According to Mr. Merrill, the following is how one would determine the proper crew ratio (2013):

Crew Ratio Formula:

$$A = (PMAI \times Surge\ UTE) \div (90\ day\ Flight\ Hour\ Restriction \div 90) \quad (1)$$
$$B(Augmented\ Crews) = A \times Augmentation\ Rate \times 1.5$$
$$C\ (Basic\ Crews) = A \times (1 - Augmentation\ Rate)$$
$$D = (B + C) \div Aircrew\ Availability\ Rate$$
$$Crew\ Ratio = D \div PMAI$$

*PMAI: Primary Mission Aircraft Inventory
*UTE: Utilization Rate

Equation 1: Crew Ratio Formula

- Example: 4 PMAI, 6 hour UTE, 330 / 90 restriction, 10% Augmentation, 90% Aircrew Availability
  - (4 x 6) / (330 / 90) = 6.55
  - 6.55 x .10 x 1.5 = .9825
  - 6.55 x .90 = 5.895
  - .9825 + 5.895 = 6.8775 / .9 = 7.642
  - 7.642 / 4 = 1.91

The difference between the calculations above from that which is executed in this research is that whole crews will be assumed for all ratios calculated. For instance, a 1.91 crew ratio is not practically possible for a 4 PMAI deployed unit; therefore, this would be rounded to 2:1. This is done by rounding 7.642 (D) up to the nearest whole number which is 8. While fractions are acceptable in crew ratios, fractions of aircrew are not possible.

An Indonesia scenario was chosen for analysis and is largely based on the scenario outlined by Rand in their *Intratheater Airlift Functional Needs Analysis (FNA).*

Included in Rand's FNA is a table of distances for airfields in their Indonesia scenario. This table of distances was exported manually into excel and then flight times were determined based on AFPAM 10-1403 block speeds for the C-130H and C-130J. For ease, the block speed for each variant for a 2000nm distance was chosen for all calculations. While this overestimates the time to locations over 2000nm apart, there are very few locations that fall into this category making the differences negligible. This particular scenario is analyzed under three different basing scenarios:

1. Operating from Paya Lebar Air Base, Singapore only
2. Operating from RAAF Base Tindal, Australia only
3. Operating from both Paya Lebar and Tindal

Given the vast nature of Indonesia's territory, the former two scenarios will be considerably more taxing on airlift than the latter.

Figure 2: Indonesia Scenario

IV. Analysis and Results

Historic Quantitative Findings

The historic data was sorted and analyzed to yield the average daily mission tasking, high end utilization, average utilization and a standard deviation for the data set. The following sections discuss the findings for Bagram and Al Udeid Air Bases respectively.

Bagram Air Base

Using a 30-day rolling average of number of missions flown per day and their respective average flight times, it is estimated that Bagram Air Base was operating at approximately a 3.6 hour utilization rate (UTE). Over the entirety of CY2010, there were 3 rolling 30 day periods that exceeded a 4.0 hour utilization rate (4.1, 4.2, and 4.2). However, given the nature of the missions, the crew days were considerably longer than the UTE rates make readily apparent. This is due to short flight durations between multiple destinations for a given mission. The average crew duty day (mission length plus 3 hours as described earlier) was 11 hours. If a 2-hour post-flight is assumed, this equals a 13 hour work cycle. While a 12 hour or less work cycle would have almost no impact on rest/work cycles, a 13 hour cycle is minimally disruptive to daily operations. Since deploying a smaller package of C-130s results in a higher crew ratio due to the whole crew rounding assumption discussed earlier, a package of 4 C-130's was assumed for analyzing the crew ratio needed for CY2010 at Bagram. Also, the extrapolated need for augmented crews was minimal (<2%); however, 5% will be used to protect against underestimating need.

		% Augmented Crews Required						90 Day Lim
		0.0%	5.0%	10.0%	15.0%	20.0%	25.0%	400
	4	1.00	1.25	1.25	1.25	1.50	1.50	PMAI
	5	1.25	1.50	1.50	1.50	1.75	1.75	4
Utilization	6	1.50	1.75	1.75	1.75	2.00	2.00	Crew Avail
Rate (UTE)	7	1.75	2.00	2.00	2.00	2.00	2.25	90%
	8	2.00	2.25	2.25	2.25	2.25	2.25	
	10	2.50	2.75	2.75	2.75	2.75	2.75	

Figure 3: Bagram Recommended Crew Ratio (400 hours in 90 Day Limit)

		% Augmented Crews Required						90 Day Lim
		0.0%	5.0%	10.0%	15.0%	20.0%	25.0%	330
	4	1.25	1.50	1.50	1.50	1.75	1.75	PMAI
	5	1.75	1.75	1.75	2.00	2.00	2.00	4
Utilization	6	2.00	2.00	2.00	2.25	2.25	2.25	Crew Avail
Rate (UTE)	7	2.25	2.25	2.50	2.50	2.50	2.50	90%
	8	2.50	2.50	2.75	2.75	2.75	2.75	
	10	3.25	3.25	3.25	3.25	3.25	3.25	

Figure 4: Bagram Recommended Crew Ratio (330 hours in 90 Day Limit)

The results above reflect the calculations described earlier in section III. Methodology. Since one can reasonably assume a continued comfort among leadership to waive the 90 day flight hour limit up to 400, a 1.5:1 crew ratio can be said to have been the minimum requirement at Bagram during CY2010. Additional summary statistics can be found in

Appendix A: Bagram Air Base Distributions and Summary Statistics.

Al Udeid Air Base

While the majority of operations from Bagram Air Base originated and terminated within Afghanistan, Al Udeid had a much different mission set in CY2010. The average UTE was 4.4, but there were 3 30-day periods that averaged above 5.0 (5.5 was the maximum daily observed UTE). The average crew day length was 12 hours (9 hour

mission plus 3 hour pre-flight duties). With the 2-hour post flight duties the total work cycle is 14 hours, only one hour more than Bagram Air Base. However, Bagram's flight hour distribution was more closely grouped around the mean than was Al Udeid's. Upon a closer look at the data and flight profiles, this difference can at least in part be attributed to the two basic mission sets being flown from Al Udeid: missions around the Gulf region and missions to Afghanistan (the latter resulting in longer flight times). There was a sizable portion (22%) of work cycles that exceeded 16 hours (11 hour mission length plus 3 hours pre-flight and 2 hours post-flight). This could result in significant circadian rhythm disruptions unless a crew ratio able to support an every other day schedule per crew is used. The mission requirements also drove the augmentation rate higher than Bagram's, but not by much. Presumably, mission planners scheduled around the 16 hour basic crew limitation to the maximum extent possible. The peak augmentation was around 5%, but the average was less than 5%.

		% Augmented Crews Required						90 Day Lim
		0.0%	5.0%	10.0%	15.0%	20.0%	25.0%	400
	4	1.00	1.25	1.25	1.25	1.25	1.50	PMAI
	5	1.25	1.50	1.50	1.50	1.50	1.50	4
Utilization	6	1.50	$\boxed{1.75}$	1.75	1.75	1.75	1.75	Crew Avail
Rate (UTE)	7	1.75	2.00	2.00	2.00	2.00	2.00	90%
	8	2.00	2.25	2.25	2.25	2.25	2.25	
	10	2.50	2.75	2.75	2.75	2.75	2.75	

Figure 5: Al Udeid Recommended Crew Ratio (400 hours in 90 Day Limit)

		% Augmented Crews Required						90 Day Lim
		0.0%	5.0%	10.0%	15.0%	20.0%	25.0%	330
	4	1.25	1.50	1.50	1.50	1.50	1.75	PMAI
	5	1.75	1.75	1.75	1.75	1.75	2.00	4
Utilization	6	2.00	2.00	2.00	2.00	2.00	2.25	Crew Avail
Rate (UTE)	7	2.25	2.25	2.25	2.25	2.50	2.50	90%
	8	2.50	2.50	2.50	2.75	2.75	2.75	
	10	3.25	3.25	3.25	3.25	3.25	3.25	

Figure 6: Al Udeid Recommended Crew Ratio (330 hours in 90 Day Limit)

Operating under the same assumption that 400 hours in 90 days will continue to be allowed, the minimum recommended crew ratio for Al Udeid for CY2010 is 1.75:1. Additional summary statistics can be found in Appendix B: Al Udeid Air Base Distributions and Summary Statistics.

Survey of Past Commanders and Directors of Operations Findings

The questionnaire was designed to be short and easy to accomplish to improve the response rate. Questionnaires were sent to ten previously deployed C-130 commanders and 10 directors of operation. The time frame for these respondents deployments will remain undisclosed to ensure anonymity. As such, the time frame does not necessarily match the data analysis timeframe of CY 2010. The subjects were also split evenly between those who were deployed to Al Udeid and Bagram Air Bases respectively. The response rate was 14 out of 20 (70%). However, of these, only five were from those deployed to Al Udeid versus nine from Bagram. All of the subjects that deployed to Bagram were Active Duty while nine out of ten of those from Al Udeid were Air Force Reservists. The part-time nature of the Reserves likely played a key role in the lower response rate.

Survey Results: Bagram

The nine respondents that deployed to Bagram had an average of 12.8 years of C-130 experience. The respondents were mixed between their preferences for a crew ratio of 2:1 (2 respondents), 1.75:1 (2 respondents) and 1.5:1 (5 respondents). One respondent noted that the Air Mobility Division seemed to task them based on their ability to generate missions, so it was difficult to make recommendations on the appropriate crew ratio since there didn't seem to be a hard contract. Eight out of nine respondents said that they had too many personnel in overhead positions. The main concerns with reducing crew ratios below their recommended amount are aircrew fatigue and availability.

Some additional concerns were that flying conditions in Afghanistan contribute heavily to crew fatigue because the missions consisted of a high number of short sorties per mission with tactical approaches, assault landings and the personal protection equipment requirements.

Survey Results: Al Udeid

The five respondents that deployed to Al Udeid had an average of 21.6 years of C-130 experience. The respondents unanimously supported a 2:1 crew ratio for Al Udeid, although one respondent said that the mission could be accomplished with a 1.75:1 with some added risk. All five respondents cited 7/30/90 day flight hour restrictions and fatigue as the most concerning problem with deploying with less than 2:1. Also of particular interest was that four out of five respondents said that their overhead manning was too high and should be reduced by two to five officers.

Some additional concerns voiced were that having a less than 2:1 crew ratio could cause significant crew fatigue issues over the deployment period. One respondent noted that it would be difficult to meet mission demands with less than a 2:1 given that a lot of missions require a 16 to 20 hour work cycle. Even if the maintenance/operations contract is to launch 75% of the aircraft on a given day, you run into significant trouble in a surge and if aircrew availability drops due to illness, ORM issues, etc. Another interesting input was that commanders should be given a little more flexibility in how many personnel they bring to a deployment based on aircrew experience.

Scenario Analysis Findings

The final method of evaluation, scenario analysis, was utilized to offer a more forward looking view of what may drive different levels of crew ratios. To begin, a table of distances between airfields in a hypothetical Indonesia area of responsibility was used to determine total flying times between those airfields. The airspeed used was the AFPAM 10-1403 block airspeeds for C-130H and C-130J aircraft. The results, by airfield combination, are given in Appendix D: Indonesia Scenario. For the purposes of the scenario, three basing assumptions were made: Tindal, Australia; Paya Lebar, Singapore; and both Tindal and Paya Lebar. In the scenario that includes both Tindal and Paya Lebar, mission length was determined by attributing the destinations to Tindal or Paya Lebar based on the shorter of the two options. For example, a C-130J flying to Sam Ratulangi takes 4.1 hours from Paya Lebar while only 3.5 hours from Tindal; in this case, 3.5 hours was used in the average flight hour calculation versus 4.1 hours. An average flying time from each basing assumption to the remaining airfields in the Indonesia AOR

are summarized below along with recommended crew ratios (based solely on hours flown) using the following assumptions: 400 hour/90 day flying hour waiver approved, 4 PMAI, 3 missions flown per day, 90% crew availability and 10% crew augmentation.

Table 2: Flying Times and Recommended Crew Ratios by Basing Option and C-130 Variant

Paya Lebar					
	Avg	Max	Min	UTE	Crew Ratio
C-130H	9.0	14.2	1.2	6.8	2.0 : 1
C-130J	8.0	13.0	1.0	6.0	1.75 : 1

Tindal					
	Avg	Max	Min	UTE	Crew Ratio
C-130H	9.0	18.4	4.0	6.8	2.0 : 1
C-130J	8.2	16.4	3.6	6.2	1.75 : 1

Paya Lebar and Tindal					
	Avg	Max	Min	UTE	Crew Ratio
C-130H	6.0	7.8	1.2	4.5	1.5 : 1
C-130J	5.4	7.0	1.0	4.1	1.25 : 1

~~**Table 2: Flying Times and Recommended Crew Ratios by Basing Option and C-130 Variant**~~

Although a 2:1 crew ratio is needed for the single base options with C-130H model aircraft, a 1.75:1 is needed for the C-130J due to their higher block airspeeds. The UTE rates contained in the table are calculated by multiplying the average flight times for a given scenario by ¾ (number of missions flown per day/PMAI). Flight times could be driven higher depending on the location of demand within the AOR.

V. Conclusions and Recommendations

Given the body of evidence contained in the historic, survey and scenario analysis, a 2:1 crew ratio should be assumed for any programming purposes. While the historic analysis points to a 1.75:1 ratio, the surveys from Al Udeid are strongly against deploying at this level. Additionally, the scenario analysis gives a plausible scenario where 2:1 is needed solely based on the 400 hours in 90 day flight hour restriction. Another major reason not to plan for less than a 2:1 crew ratio is because of the possibility for significant circadian rhythm disruptions. Whereas it is true that a 1.75:1 crew ratio will mathematically meet mission requirements in most plausible scenarios, less quantifiable factors would significantly increase the likelihood of mission failure due to fatigue and scheduling conflicts leading to crew availability issues in high UTE rate scenarios. In practical terms, fatigue could lead to failure in a few ways: mission cancellation due to very high operational risk management scores, air crews refusing to fly due to fatigue and the worst case; it could be causal in a mishap.

If it is determined that the C-130 crew force needs to be reduced to meet budget constraints, this research can be used as a starting point for a thorough risk analysis associated with that action. While this research solely studied C-130 crew ratios by itself, it is possible to mitigate a 1.75:1 programmed crew ratio to fulfill a 1.75:1 deployed crew ratio by leveraging other assets. For instance, TRANSCOM and AMC may decide that they can adequately meet intratheater airlift demand with reduced C-130 manning when coupled with existing C-17 capability. However, given that the C-17 will likely be

performing intertheater and intratheater airlift in most conflicts, this will have to be studied closely.

Recommendations for Future Research

1. Consideration should be given for including crew ratio calculations in the AFPAM 10-1403 to aid deployment planners in determining the optimal deployment package. While it appears that the correct crew ratios are worked out in the end either through internal modeling, trial and error or other methods, crew ratio calculations should be included in the mobility planner's source document.

2. The MCRS-16 states that "the C-130 crew force structure cannot sustain steady state operations in combination with a long duration irregular warfare campaign" (United States Transportation Command, 2010, p. 6). This statement, if not already fully addressed, should be validated or invalidated. If it is found to be valid, further research should be done to determine how this impacts crew ratio planning in the future before C-130 aircrew manning is changed.

3. The overhead packages currently planned need to be reassessed in light of near unanimity in thinking there are too many airmen deployed in these positions. Additionally, since many of the airmen deployed in overhead positions are rotated into the flying schedule, research should be done to understand if this is masking any possible shortfalls in the deployed aircrew numbers. For instance, if there are just enough aircrews deployed to meet mission demand, are surge crews and DNIF covers being pulled from overhead positions? Is this the right way of structuring deployed

C-130 manning packages? Answering these questions may require studying the way scheduling is done at deployed locations. For instance, one method could be to have limited overhead billets (commander, director of operations and perhaps an assistant director of operations). To fill the remaining overhead billets, flight crews could be rotated through these positions to reduce fatigue and individual flight hour accumulation. This effectively would result in slashing overhead billets while maintaining a higher crew ratio.

4. Secret level analysis should also be done to further the research contained herein to ensure that all C-130 participation in various Operational Plans are adequately manned. This was a major limitation in this research and is likely the most important item to address ahead of any decisions on the manning levels for C-130 squadrons. In addition, an expanded historic analysis for the entirety of Operations Iraqi and Enduring Freedom would ensure that ebbs and flows in demand are accurately captured.

Appendix A: Bagram Air Base Distributions and Summary Statistics

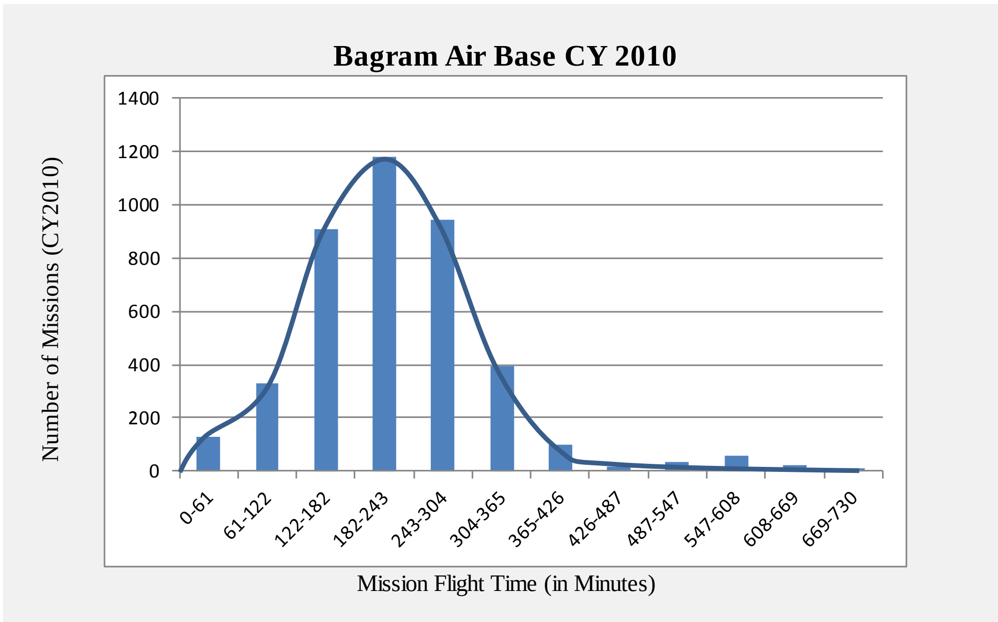

Figure 7: Bagram AB Flight Hour Distribution (in minutes)

Table 3: Summary Statistics (OAIX)

Bagram Air Base (OAIX)			
	Scheduled Mission Minutes	Actual Mission Minutes	Flight Time
Avg Minutes	494.8	473.7	226.6
Avg Hours (Mean)	8.2	7.9	3.8
Max (Minutes)	2200.0	4705.0	730.0
Max (Hours)	36.7	78.4	12.2
Min (Minutes)	15.0	15.0	15.0
Std Deviation	193.3	177.1	101.0
Median (Minutes)	505.0	482.0	217.0
(Hours)	8.4	8.0	3.6
Mode (Minutes)	490.0	465.0	205.0
(Hours)	8.2	7.8	3.4

~~Table 3: Summary Statistics (OAIX)~~

Appendix B: Al Udeid Air Base Distributions and Summary Statistics

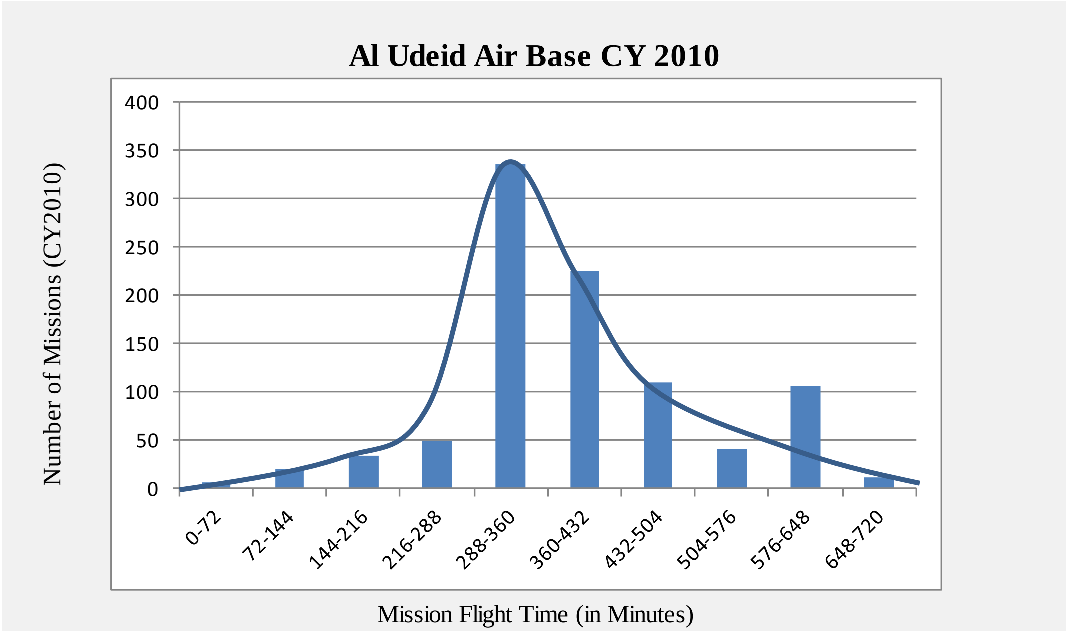

Figure 8: Al Udeid AB Flight Hour Distribution (in minutes)

Table 4: Summary Statistics (OTBH)

Al Udeid Air Base (OTBH)			
	Scheduled Mission Minutes	Actual Mission Minutes	Flight Time
Avg Minutes	560.1	540.0	387.8
Avg Hours (Mean)	9.3	9.0	6.5
Max (Minutes)	910.0	928.0	720.0
Max (Hours)	15.2	15.5	12.0
Min (Hours)	22.0	22.0	22.0
Std Deviation	140.5	150.3	121.3
Median (Minutes)	565.0	542.0	364.0
(Hours)	9.4	9.0	6.1
Mode (Minutes)	550.0	520.0	321.0
(Hours)	9.2	8.7	5.4

~~Table 4: Summary Statistics (OTB~~

Appendix C: Commander and DO Questionnaire

Questionnaire: ***Determining the Optimal Deployed C-130 Crew Ratio***

You are receiving this questionnaire as a prior deployed C-130 Commander or Director of Operations. The purpose of the research is to analyze quantitative and qualitative data to determine the optimal deployed crew ratios for a range of future operations; this questionnaire will be an important instrument for the qualitative side of the research. By responding, you will be providing important first-hand information that could have a part in shaping discussions on the future C-130 force structure.

Background:

As the Air Force seeks efficiencies to mitigate the certainty of shrinking budgets, force structure must be looked at to determine if it is properly sized. Deployed crew ratios have varied wildly over the duration of Operations Enduring and Iraqi Freedom. This variation will be studied for correlations between crew ratio and operations tempo, but a correlation does not by itself account for all factors corresponding to a needed crew ratio.

The data obtained from this questionnaire will be used to identify some possible effects on needed crew ratios that are not readily apparent in the quantitative analysis. This is the only planned survey, but individual follow up may be required for clarification purposes.

Please note the following:

Benefits and risks: There are no personal benefits or risks for participating in this study. Your participation in completing this questionnaire should take less than 15 minutes.

Confidentiality: Questionnaire responses are confidential. Your identity will not be associated with any responses you give in the final research report. No individual data will be reported; only data in aggregate will be made public. I understand that the names and associated data I collect must be protected at all times, only be known to the researcher, and managed according to the Air Force Institute of Technology (AFIT) interview protocol. At the conclusion of the study, all data will be turned over to the advisor and all other copies will be destroyed.

Voluntary consent: Your participation in this study is completely voluntary. You have the right to decline to answer any question, to refuse to participate or to withdraw at any time. Your decision of whether or not to participate will not result in any penalty or loss of benefits to which you are otherwise entitled. Completion of the questionnaire implies your consent to participate.

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Wright-Patterson AFB, OH

The sponsor for this research is Mr. Don Anderson, Deputy Chief AMC/A9, at Air Mobility Command Scott Air Force Base, Illinois.

Process:

Please complete this survey **electronically** and return it to: **kevin.campanile.1@us.af.mil** as soon as possible but no later than **28 February 2014**. If you have questions, I can be reached at 325-829-4106 (Cell).

1. Personal/Demographic Questions:
    a. Name:
    b. Rank:
    c. Current Duty Title:
    d. Deployed Duty Title (C-130 Deployed Squadron…highlight one or both): Commander / DO
    e. Time spent in deployed position:
    f. Indicate time period deployed in the above position (i.e.: May-Sep 2012):
    g. Component (highlight one): Active Duty / Reserve / ANG
    h. Years of C-130 experience:
2. Please answer the following questions relating to deployed C-130 manning (the researcher has data on historic crew ratios by location and date; your answers will be reviewed along with the crew ratio for your time period):
    a. Was your overall deployed manning adequate for mission accomplishment (flight crews and overhead)?
        i. Yes
        ii. No
    b. Did you have excess manning?
        i. Yes, overhead
        ii. Yes, flight crews
        iii. Yes, both overhead and flight crews
        iv. No
    c. If so, approximately how many personnel and position titles (as specific as you can recall)?
        i. _______________
    d. What do you feel would have been the optimal crew ratio for your deployment?
        i. ____
    e. Do you feel that you could have accomplished your mission with a lower crew to aircraft ratio?
        i. Yes (how many fewer crews______)
        ii. No

f. Did you utilize excess flight crew manning to fill overhead positions?
    i. Yes
    ii. No
    iii. Didn’t have excess flight crews
g. Did you utilize excess overhead to fill flying positions?
    i. Yes
    ii. No
    iii. Didn’t have excess overhead
h. What was your average (or planned) crew availability rate (to the best of your knowledge)?
    i. ______(i.e.: 86%...accounting for DNIF, emergency leave, etc)
i. On a scale from 1-5 (1- Strongly Agree, 3- Neither Agree nor Disagree, 5- Strongly Disagree), please assess how strongly you feel the following would become problematic for mission accomplishment if you had deployed with 1 fewer flight crew?
    i. ___ Grounding crews due to 7/30/90 day flight hour restrictions
    ii. ___ Mission cancelations due to crew fatigue
    iii. ___ Mission cancelations due to crew availability
    iv. ___ Other: ____
j. Please use the below space to indicate any additional comments on the research topic:

Appendix D: Indonesia Scenario

Indonesia Vignette Airfield Locations, Sizes, and Elevations

	Name	Type	Latitude (+north, −south)	Longitude (east)	Length (ft)	Width (ft)	Elevation (ft)
1	Paya Lebar	L1	1.360	103.910	12,401	200	65
2	Tindal	L1	−14.521	132.378	9,003	150	443
3	Iswahyudi	L2	−7.616	111.434	8,448	92	361
4	Moses Kilangin	L2	−4.528	136.887	7,841	148	103
5	Mutiara	L2	−0.919	119.910	6,781	98	284
6	Tjilik Riwut	L2	−2.225	113.943	6,890	98	82
7	Batujajar	L3	−6.904	107.476	5,420	65	2,500
8	Gorda	L3	−6.140	106.344	5,250	330	40
9	Tambolaka	L3	−8.597	120.477	5,905	98	161
10	Bali International	L3	−8.748	115.167	9,790	148	14
11	Dominique Edward Osok	L3	−0.895	131.285	6,070	90	10
12	Kaimana	L3	−3.645	133.696	5,249	98	19
13	Mopah	L3	−8.520	140.418	6,070	98	10
14	El Tari	L3	−10.172	123.671	4,175	210	335
15	Jalaluddin	L3	0.637	122.850	7,407	100	105
16	Presidente Nicolau Lobato International	L3	−8.547	125.525	6,065	98	25
17	Sam Ratulangi	L3	1.549	124.926	8,693	148	264
18	Pinang Kampai	L3	1.609	101.434	5,905	98	55
19	Sultan Iskandarmuda	L3	5.524	95.420	8,184	148	65
20	Pangsuma	L3	0.836	112.937	3,294	75	297

Figure 9: Indonesia Scenario Airfields

Distances (NM): Airfields in Indonesia Scenario AOR	Paya Lebar	Tindal	Iswahyudi	Moses Kilangin	Mutiara	Tjilik Riwut	Batujajar	Gorda	Tambolaka	Bali Internat'l	Dominique Ed Osok	Kiamana	Mopah	El Tari	Jalaluddin	Pres. Nicolau	Sam Ratulangi	Pinang Kampai	Sultan Iskandarmuda
Tindal	1944																		
Iswahyudi	703	1302																	
Moses Kilangin	2012	657	1532																
Mutiara	971	1103	648	1042															
Tjilik Riwut	640	1320	357	1384	367														
Batujajar	541	1539	240	1765	828	479													
Gorda	474	1618	316	1830	872	513	82												
Tambolaka	1159	786	541	1010	463	547	781	855											
Bali Internat'l	908	1070	232	1321	550	399	471	549	316										
Dominique Ed Osok	1651	822	1256	401	684	1045	1472	1529	796	1074									
Kiamana	1815	658	1352	199	844	1189	1581	1645	844	1148	220								
Mopah	2266	595	1725	319	1310	1628	1964	2036	1185	1500	713	497							
El Tari	1370	574	743	857	600	752	982	1059	212	511	720	715	998						
Jalaluddin	1139	1073	845	898	200	562	1027	1071	573	728	515	701	1188	652					
Pres. Nicolau	1425	540	840	720	568	790	1079	1152	300	616	575	570	885	147	575				
Sam Ratulangi	1263	1063	979	806	336	698	1164	1207	666	851	409	612	1108	709	136	608			
Pinang Kampai	150	2081	817	2161	1121	786	627	551	1295	1032	1800	1964	2414	1507	1288	1567	1412		
Sultan Iskandarmuda	567	2511	1243	2561	1520	1206	1040	960	1725	1462	2187	2363	2826	1937	1672	1993	1786	431	
Pangsuma	543	1480	516	1474	432	194	569	576	725	591	1108	1276	1740	922	596	942	722	693	1088

Figure 10: Distance Chart for Indonesia AOR Airfields

C-130H En Route Times (Block Speed of 273 NM/HR)	Paya Lebar	Tindal	Iswahyudi	Moses Kilangin	Mutiara	Tjilik Riwut	Batujajar	Gorda	Tambolaka	Bali Internat'l	Dominique Ed Osok	Kiamana	Mopah	El Tari	Jalaluddin	Pres. Nicolau	Sam Ratulangi	Pinang Kampai	Sultan Iskandarmuda
Tindal	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iswahyudi	2.6	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Moses Kilangin	7.4	2.4	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mutiara	3.6	4.1	2.4	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tjilik Riwut	2.4	4.9	1.3	5.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Batujajar	2.0	5.7	0.9	6.5	3.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gorda	1.7	5.9	1.2	6.7	3.2	1.9	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tambolaka	4.3	2.9	2.0	3.7	1.7	2.0	2.9	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bali Internat'l	3.3	3.9	0.9	4.9	2.0	1.5	1.7	2.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dominique Ed Osok	6.1	3.0	4.6	1.5	2.5	3.8	5.4	5.6	2.9	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kiamana	6.7	2.4	5.0	0.7	3.1	4.4	5.8	6.0	3.1	4.2	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mopah	8.3	2.2	6.3	1.2	4.8	6.0	7.2	7.5	4.4	5.5	2.6	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
El Tari	5.0	2.1	2.7	3.2	2.2	2.8	3.6	3.9	0.8	1.9	2.6	2.6	3.7	0.0	0.0	0.0	0.0	0.0	0.0
Jalaluddin	4.2	3.9	3.1	3.3	0.7	2.1	3.8	3.9	2.1	2.7	1.9	2.6	4.4	2.4	0.0	0.0	0.0	0.0	0.0
Pres. Nicolau	5.2	2.0	3.1	2.6	2.1	2.9	4.0	4.2	1.1	2.3	2.1	2.1	3.3	0.5	2.1	0.0	0.0	0.0	0.0
Sam Ratulangi	4.6	3.9	3.6	3.0	1.2	2.6	4.3	4.4	2.4	3.1	1.5	2.3	4.1	2.6	0.5	2.2	0.0	0.0	0.0
Pinang Kampai	0.6	7.7	3.0	7.9	4.1	2.9	2.3	2.0	4.8	3.8	6.6	7.2	8.9	5.5	4.7	5.8	5.2	0.0	0.0
Sultan Iskandarmuda	2.1	9.2	4.6	9.4	5.6	4.4	3.8	3.5	6.3	5.4	8.0	8.7	10.4	7.1	6.1	7.3	6.6	1.6	0.0
Pangsuma	2.0	5.4	1.9	5.4	1.6	0.7	2.1	2.1	2.7	2.2	4.1	4.7	6.4	3.4	2.2	3.5	2.7	2.5	4.0

Figure 11: Flight Hours Chart for Indonesia AOR Airfields C-130H

C-130J Enroute Times (Block Speed of 308 NM/HR)	Paya Lebar	Tindal	Iswahyudi	Moses Kilangin	Mutiara	Tjilik Riwut	Batujajar	Gorda	Tambolaka	Bali Internat'l	Dominique Ed Osok	Kiamana	Mopah	El Tari	Jalaluddin	Pres. Nicolau	Sam Ratulangi	Pinang Kampai	Sultan Iskandarmuda
Tindal	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Iswahyudi	2.3	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Moses Kilangin	6.5	2.1	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mutiara	3.2	3.6	2.1	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tjilik Riwut	2.1	4.3	1.2	4.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Batujajar	1.8	5.0	0.8	5.7	2.7	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gorda	1.5	5.3	1.0	5.9	2.8	1.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tambolaka	3.8	2.6	1.8	3.3	1.5	1.8	2.5	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bali Internat'l	2.9	3.5	0.8	4.3	1.8	1.3	1.5	1.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dominique Ed Osok	5.4	2.7	4.1	1.3	2.2	3.4	4.8	5.0	2.6	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kiamana	5.9	2.1	4.4	0.6	2.7	3.9	5.1	5.3	2.7	3.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mopah	7.4	1.9	5.6	1.0	4.3	5.3	6.4	6.6	3.8	4.9	2.3	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
El Tari	4.4	1.9	2.4	2.8	1.9	2.4	3.2	3.4	0.7	1.7	2.3	2.3	3.2	0.0	0.0	0.0	0.0	0.0	0.0
Jalaluddin	3.7	3.5	2.7	2.9	0.6	1.8	3.3	3.5	1.9	2.4	1.7	2.3	3.9	2.1	0.0	0.0	0.0	0.0	0.0
Pres. Nicolau	4.6	1.8	2.7	2.3	1.8	2.6	3.5	3.7	1.0	2.0	1.9	1.9	2.9	0.5	1.9	0.0	0.0	0.0	0.0
Sam Ratulangi	4.1	3.5	3.2	2.6	1.1	2.3	3.8	3.9	2.2	2.8	1.3	2.0	3.6	2.3	0.4	2.0	0.0	0.0	0.0
Pinang Kampai	0.5	6.8	2.7	7.0	3.6	2.6	2.0	1.8	4.2	3.4	5.8	6.4	7.8	4.9	4.2	5.1	4.6	0.0	0.0
Sultan Iskandarmuda	1.8	8.2	4.0	8.3	4.9	3.9	3.4	3.1	5.6	4.7	7.1	7.7	9.2	6.3	5.4	6.5	5.8	1.4	0.0
Pangsuma	1.8	4.8	1.7	4.8	1.4	0.6	1.8	1.9	2.4	1.9	3.6	4.1	5.6	3.0	1.9	3.1	2.3	2.3	3.5

Figure 12: Flight Hours Chart for Indonesia AOR Airfields C-130J

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14. ABSTRACT
As the Air Force begins to face budget limitations, every program must be analyzed for efficiencies. AMC is in the process of trying to find such efficiencies to help mitigate cuts. By taking a fresh look at intratheater airlift requirements and historical data, AMC can justify its current C-130 manning or find that a new mix can both meet COCOM requirements and become more efficient. The research goal is to guide a discussion within AMC that will determine the optimal deployed crew. This will lead to further discussions on proper C-130 squadron manning and appropriate C-130 component makeup. The focus of this research is to find the optimal crew ratio for deployed C-130s from both a historic and forward looking perspective. The research contains quantitative analysis in the form of analyzing historical data, and has a qualitative component in the form of questionnaires of past deployed C-130 commanders and directors of operation. Additionally, a high UTE rate scenario is analyzed to aid in warding off a myopic decision based solely on history. All of this taken together yields a quant[79]itative decision tempered by less measurable factors to give a holistic view of crew ratio planning.

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